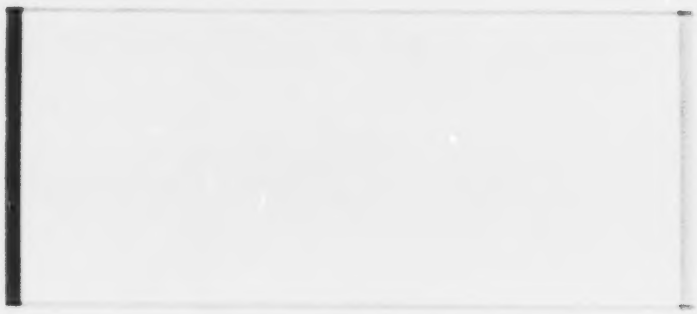

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Glenayre electronics

TP 5033E

IMPROVED TRAIN CONTROL TRANSPONDER

Prepared For The

Transportation Development Centre
of Transport Canada

By

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November 1983

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17. Abstract

The purpose of this contract was to investigate failures in the hermetic seal of the Glenayre Model 6110 Train Control Transponder. Used in a train Location, Identification and Control System, the transponder is installed on railway cross-ties, and serves as a means of calibrating the locomotion odometer and verifying the location of the train. Over a period of between 1 and 4 years, failures of the seal allowed the entry of moisture that damaged the transponder circuitry.

The original design of the transponder involved the use of a suitable compound to fill a parallel-sided groove between the lid and the transponder body. It was found that this method invariably led to incomplete filling of the groove which was impossible to detect during manufacturing.

The seal was redesigned to provide for a vertical "v" shaped groove, that allowed the sealing compound to be flowed in, filling the groove from the bottom up to avoid air pockets.

Results of failure analysis, high speed and low tempurature testing are reported.

18. Key Words	19. Distribution Statement
Vehicle Transponder, Train Location Identification and Control	Limited number of copies available from the Transportation Development Centre

20. Security Classification (of this report)	21. Security Classification (of this page)	22. No. of Pages	23. Price
Unclassified	Unclassified	21	Nil

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15. Remarques additionnelles	16. Agent de projet — CDT Micha Avni

17. Résumé

Ce rapport fait le point sur les travaux entrepris pour trouver la cause de la mauvaise tenue du joint d'étanchéité du transpondeur Glenayre modèle 6110. Cet élément des systèmes LIC se fixe aux traverses de la voie et sert à étalonner l'odomètre des locomotives et à repérer les trains dans le réseau. Ce joint se dégrade au bout d'un maximum de 4 ans, laissant l'humidité pénétrer dans le boîtier du transpondeur et endommager les composants qui s'y trouvent.

Dans sa forme première, le boîtier comportait une rainure à faces parallèles dans laquelle venait s'asseoir le couvercle du transpondeur, l'étanchéité du joint étant assurée par un produit de remplissage approprié. L'examen de ce joint sur toute une série de transpondeurs a révélé que le produit d'étanchéité ne réussissait jamais à remplir complètement la rainure et qu'au surplus, cela était indétectable par les contrôles habituels de fabrication. La rainure du boîtier a donc été redessinée - elle est maintenant en V - pour corrigercette faiblesse attribuable à la formation de poches d'air dans le joint.

Le rapport fait la lumière sur le mode de dégradation des joints et donne le résultat des essais aux basses températures et des essais de repérage aux hautes vitesses.

18. Mots-clés	19. Diffusion
Transpondeur, système LIC	Le CDT dispose d'un nombre limité d'exemplaires

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APPENDIX I - (Descriptive Brochure)

GL600 DIGITRAC SYSTEM

1. INTRODUCTION

The purpose of this contract was to investigate a certain problem area in the field operation of the Model 6110 Transponder used in the Location, Identification and Control (LIC) System, namely, the failure of the external enclosure to prevent the ingress of moisture during extended periods of field deployment.

The transponder is installed on railway cross-ties, between the rails, and by virtue of its known fixed location serves as a means of calibration of a locomotive on-board odometer and also as a means of positive identification that a train has crossed certain locations on the track called control points which serve to separate trains and thereby prevent conflicting track use with the attendant possibility of accident. Further information about the Transponder and the associated equipment may be found in the product brochure in Appendix I.

Transponders consist of an electronic circuit board assembly enclosed in a rugged weatherproof package. They are designed to last a long time, once installed, and to be maintenance-free. To accomplish this, the electronic design involves extremely low electrical stress cn all components and the fabrication techniques are such as to ensure good integrity of the electronics assembly. The packaging employs resiliant and rugged ABS as an enclosure material, and includes a hermetic seal which must achieve complete exclusion of moisture in order that the transponder should successfully fulfill its design objective.

During the course of long-term field trials which began in 1977, it was found that the hermetic seal on many transponders was, after a period of between 1 and 4 years of field service, failing to exclude moisture from the electronic circuit assembly, and failure of the transponder circuitry was occurring from electrical short circuit and corrosion damage, both of which were a direct result of this moisture entry.

2. WORK DONE AND RESULTS

To determine the cause of the failure of the hermetic seal, a detailed investigation of the design of the transponder package and the fabrication methods by which it was assembled and sealed was conducted. An outside expert was consulted to work with qualified company design personnel. The result was the following set of conclusions:-

A) The fundamental design approach using a two-piece shell, glued together and then sealed, was sound.

B) The detailed design of the joint and the method of inserting the sealing compound made it likely that an incomplete seal would be made in a significant number of cases.

C) A relatively straightforward change in the design of the joint would likely eliminate the problem of poor seal integrity.

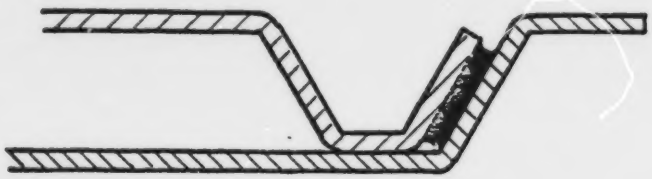
The original joint design left a parallel-sided groove around the transponder. The sealing process involved filling this groove with a suitable compound. Failures resulted from incomplete sealing of the groove, and this was difficult to avoid, and impossible to detect, during the fabrication process.

To obviate the problem, the joint design was changed so that the "groove" to be filled was V-shaped and thus was much more conducive to successful sealing.

Figure 1 shows the two joint designs and illustrates the principles in the above analysis.

To prove the new design approach, the vacuum forming mold for the transponder was modified and a total of 100 transponder cases of the new design were fabricated. These were used for re-packaging when transponders which had failed in service were recalled and repaired. Repaired transponders were re-deployed and statistics maintained on the degree to which the new design successfully prevented the ingress of moisture. In addition, extensive water immersion and temperature cycling tests were made in the laboratory.

Over the period of these studies, a total of 112 transponders were examined and 24 exhibited failure of the seal. A total of 79 were re-packaged using the new case. No instances of water entering the new transducer case have been observed.



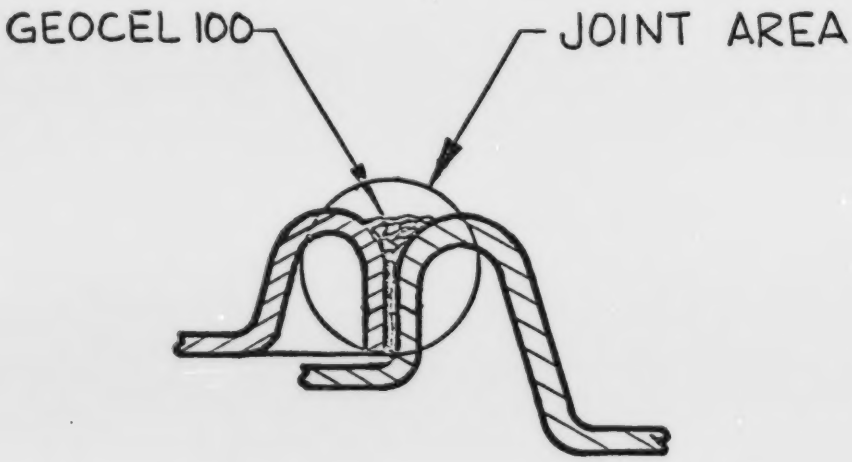


Figure 1 Joint Design

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3. ADDITIONAL WORK AND RESULTS

In addition to the testing and re-design associated with improving the transponder package, three other tasks were completed and are reported below:-

3.1 Failure Analysis

A total of 112 transponders were examined in the course of this project and the results are categorized as follows:-

	Lot 1	Lot 2	Lot 3	Overall
No fault found	33 +	5 +	4 =	42
Leaking seal	20 +	4 +	0 =	24
Physical damage	6 +	16 +	4 =	26
Circuit assembly failure	9 +	9 +	2 =	20
Total				112

The three different lots of transponders were received and the results summed to give overall results. Lot 1 was the oldest. Trends are observable in the "no fault found" category and in the "leaking seal" category which represent a falling incidence. The physical damage category results from random occurrences. The circuit assembly failure category also shows a falling incidence which truly represents elimination of a problem component used in early models of the transponder.

3.2 High-Speed Testing

Using the 12 foot rotating arm test fixture recently constructed at GLENAYRE, the DIGITRAC transponders were tested up to a maximum speed of 130 kilometers per hour. An interrogator and controller were set up to operate in the lab and special test software was written to record the number of missed readings. No wrong numbers or incorrect output data were observed over a total of 267,000 readings.

The missed transponder rate, averaged over all ranges up to 24 inches and speeds up to 100 mph was 0.2%.

3.3 Low Temperature Testing

Low temperature testing of the interrogator and transponder was done at 0, -10, -20, -35, -40, -44, -50, -55, -60, -65, and -71 degrees C. At each temperature the equipment was soaked to ensure temperature stability, then the interrogator was turned on and it's oscillator frequency measured. The maximum variation in frequency was 0.25%. Then the equipment was removed from the low temperature chambers and its operation quickly checked. In every case, normal transponder readings were made. The current drain at the lowest temperature was less than 1/2 of that at 25 degrees C.

4. CONCLUSION

This project enabled rectification of a problem which occurred during field service experience with the GLENAYRE Model 6110 Transponder. The result is that a new moisture-proof package design has been developed and tested successfully.

Allowance for fabrication of up to 100 prototype packages, for field testing, gave strong numerical support that the new design is successful.

Subsequent to completion of this work, a large order of 400 transponders was received from Canadian National Railway. With this quantity it was found that an injection mold (rather than the vacuum-forming dies used for the prototypes) was cost justified. A mold is now being fabricated using the design which was proven during this project. Thus all items of the work statement have been completed although the injection mold is being fabricated at GLENAYRE's expense.

IMPROVED TRAIN CONTROL TRANSPONDER
TDC FILE NO. D1465-381-1 SERVICE CONTRACT NUMBER 4702

Prepared by

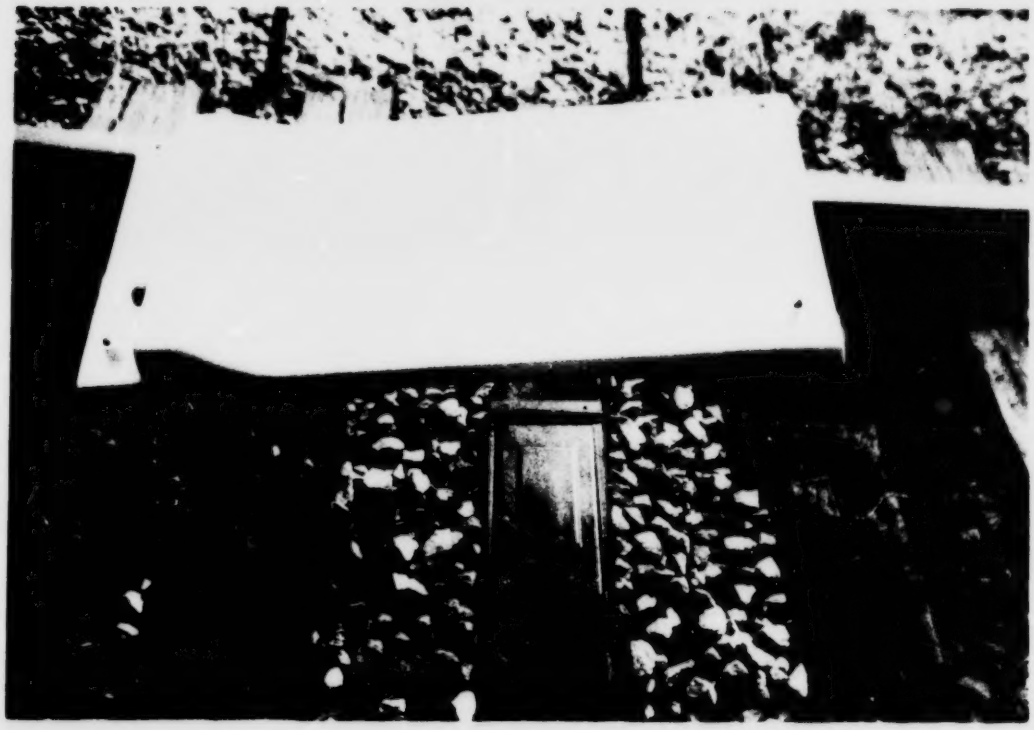
Glenayre Electronics Ltd.

For The
Transportation Development Centre
Of Transport Canada

GL 6000

DIGITRAC SYSTEM

Glenayre electronics



GENERAL DESCRIPTION

The DIGITRAC system provides data transfer between moving vehicles and the wayside. The transfer occurs at fixed locations precisely defined by the position of the equipment.

The system comprises three units: the transponder, interrogator, and controller. Each unit is ruggedly constructed to withstand the extremes of temperature, weather, and vibration encountered in the transportation environment.

The equipment has been designed for flexibility of use and can readily be interfaced to various display, recording, or processing equipment.

Applications include vehicle location, electronic sentry, vehicle identification, route control, and trip recording. Powerful data acquisition techniques assure reliable and secure data transfer at vehicle speeds from zero to over 100 mph.

FEATURES

- *Vehicle-to-Wayside or Wayside-to-Vehicle applications*
- *Four-digit, highly secure data transfer*
- *Reliable solid-state circuitry*
- *High performance micro-computer controller*
- *Hermetically sealed transponder*
- *Serial asynchronous output at 300 to 9600 Baud*
- *RS232-compatible interface*
- *FCC approved for unlicenced operation*

TECHNICAL DESCRIPTION

the DIGITRAC Controller comprises three major circuit elements; the power supply, the RF receiver, and the digital processor.

The power supply for on-vehicle installations is a modified flyback DC-DC converter. Featured in this circuit are: reverse polarity, high voltage and transient protection, single fuse components protection in case of short circuits, and output regulation. It is suitable for direct connection to locomotive 72 VDC supply. For wayside installations a 110 VAC line input power supply is provided.

The rf section receives and demodulates the transponder data signal.

The digital processor is a micro-computer based circuit which demodulates the DPSK sub-carrier, locks onto the reference frequency, monitors for interrogator failure, creates a synchronous data clock, analyses burst transponder data to validate transponder numbers, and provides an external serial output interface via a RS232 port to the outside world. An LSI USART is used to generate serial asynchronous character data output under the control of the micro-computer.

The DIGITRAC Interrogator generates a 200 KHz electromagnetic field. This electromagnetic field is strong enough in the vicinity of the interrogator field (10 to 24 inches separation) to energize the passive transponder by inductive coupling. The interrogator also provides antenna circuitry to receive the HF transmission from the transponder, as well as interface circuitry to the transponder reader for power, frequency reference and RF data.

The DIGITRAC Transponder is an inductively powered data source. Its circuitry can be divided into four sub-elements. The 200 KHz power receiver, the logic data generator, the DPSK synthesizer, and the HF transmitter.

The 200 KHz power receiver inductively receives the electromagnetic radiation from the interrogator and utilizes this to provide a frequency reference for the logic circuitry and, after rectification and filtering, to provide the DC supply voltage to power the transponder.

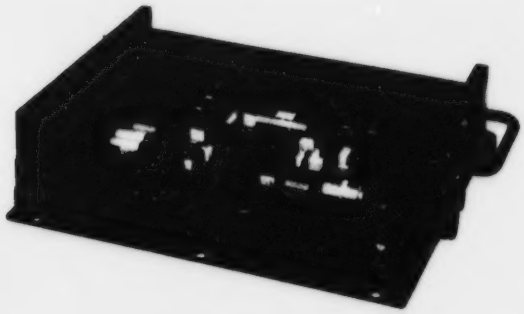
The logic data circuit generates a 4 decimal digit serial code at a continuous rate using the 200 KHz interrogator frequency as a clock reference. Thus ten thousand highly secure codes can be generated for a wide range of applications.The serial binary data stream is then fed into the DPSK synthesizer for modulation.

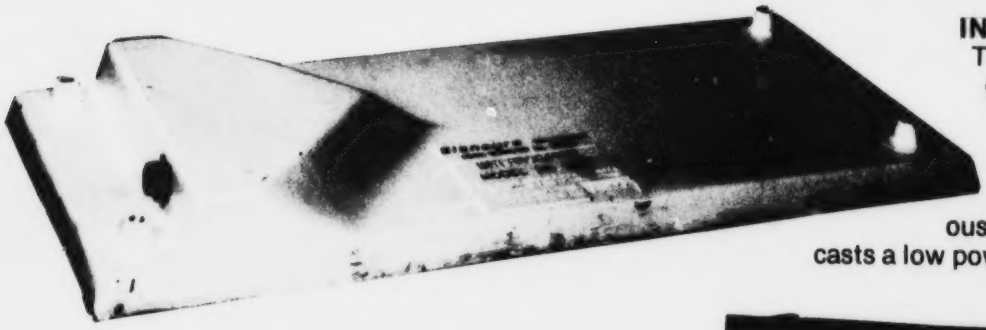
The DPSK synthesizer circuitry generates a 25 KHz sinewave data carrier and differentially shift keys the phase of the logic generator. The information is then fed to the RF stage for transmitting.

The RF transmitter uses a third overtone quartz crystal oscillator to ensure accurate, stable operation throughout an operating temperature range of -40°C to +70°C (-40°F to +158°F). The transmitter will continuously send the transponders' identification data as long as the transponder remains within the electromagnetic field of the interrogator. Accurate data transfer is obtainable from the DIGITRAC transponder at vehicle speeds from zero to well over 100 mph.

The design of our DIGITRAC system permits custom features such as multiple number storage and advanced number interpretation in the reader itself.

DIGITRAC CONTROLLER
The DIGITRAC Controller is a microcomputer-based data acquisition and control unit. It interfaces to vehicle power directly and also supplies power to the interrogator unit. Transponder data signals are demodulated in the reader and checked for integrity. After data verification, the validated transponder number is available at the reader output interface.

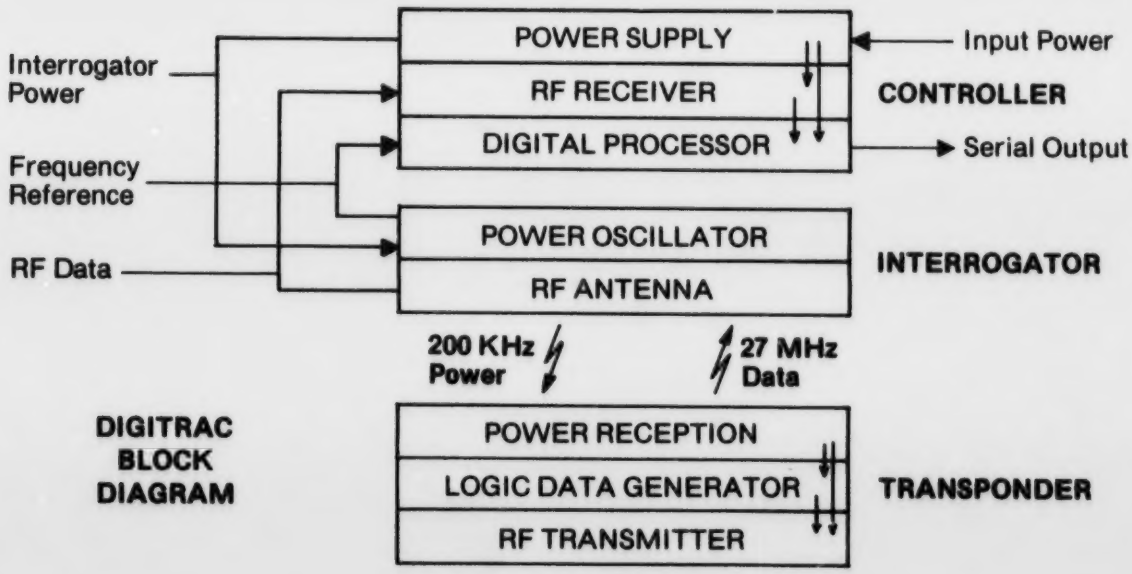




INTERROGATOR
The DIGITRAC interrogator is a hermetically sealed unit which is normally mounted on the underside of the vehicle. It continuously generates and broadcasts a low power electromagnetic field.

TRANSPONDER
The DIGITRAC transponder is a small hermetically sealed unit which is normally mounted on the wayside roadbed at fixed point location. When inductively energized the transponder will transmit a four fixed decimal digit data pulse. BCH error check security techniques protect all transmitted data to ensure accuracy.

Note that the controller and interrogator may alternatively be mounted at the wayside with transponders on the vehicles, for vehicle tracking applications. In this configuration a real-time clock is incorporated in the Controller.



DIGITRAC BLOCK DIAGRAM

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SPECIFICATIONS

Transponder — Model 6110

Number of digits	4 decimal
Number of selection	Fixed at time of manufacture (external selection optional)
Power requirements	Powered by inductive coupling with Interrogator.
Operating Distance	25 cms to 61 cms (10 in. to 24 in.)
Temperature	-40°C to +70°C
Environment	Unaffected by snow, ice, dirt, water. May be fully immersed.
Dimensions	38 x 20 x 2 cm (15 x 8 x ¾ in.)
Weight	1.4 kg. (3 lbs)

Interrogator Coil Unit (ICU) — Model 6215

Connections	Input power and received data through single MS-type connector.
Distance from Controller	Up to 30 meters (100 ft)
Temperature	-40°C to +60°C
Environment	Unaffected by snow, ice, dirt, water. No conducting screen may be placed between the ICU and the transponder. The ICU must be at least 15 cms (6 inches) from any conducting surface.
Dimensions	86 x 39 x 8 cms (34 x 15 x 3 in.)
Weight	6.8 kg (15 lbs)

Controller — Model 6502

Power required	Less than ½ amp at 72 vdc
Output Interface	RS232 compatible serial asynchronous
Temperature	-18°C to +55°C
Environment	Suitable for the physical and electrical environment of a locomotive.
Dimensions	41 x 29 x 9 cms (16 x 11.5 x 3.5 in.)
Weight	5.5 kg (12 lbs)

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